ON THE SPECTRA OF THE ORION NEBULOSITIES[1]

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In the course of the nebular investigations at the Lowell Observatory, spectrograms have been secured of different parts of the Great Orion Nebula and of the neighboring nebulosities; and it will perhaps be of interest at this time to give briefly some of the results. These could be given more advantageously pictorially with the use of a lantern, but owing to the difficulty of reproducing without misleading imperfections such delicate plates, it will be necessary here to resort to descriptions of some of the more interesting and typical spectra.

At this point it may be helpful for the reader to refer to page 496 of Miss Clerke's *Problems in Astrophysics* where is reproduced a photograph of the constellation of *Orion* made by Prof. W. H. Pickering, in 1890, from Mount Wilson. This plate revealed the great encircling cloud of nebulosity in *Orion*, and thus has the distinction of furnishing the first of that already long list of valuable astronomical discoveries made from the vantage point of Mount Wilson.

On this plate it will be seen that the great encircling nebulous band begins a little way southeast of γ *Orionis* and swings to the eastward and southward, passing at a distance the belt and sword-handle of *Orion;* then to the westward passing near κ and curving inside *Rigel* to the northward to η or possibly to the belt. All the nebulosities to be discussed spectrally in this paper lie within the confines of this enveloping cloud: the nebula N. G. C. 2068 is in the dark spot northeast of ζ, being the most distant from the Great Orion Nebula about θ.

With the nebular spectrograph attached to the 24-inch refractor, a twenty-hour exposure was made for the spectrum of the brighter part of the Great Nebula. For this plate the slit of the spectrograph was N-S near the Trapezium. The negative records many emission lines between the well-known brilliant nebular lines λ 3727 and λ 5007, and a weak continuous spectrum. One recognizes no dark lines crossing the continuous spectrum, but this is not surprising, for experience with other nebulae—as that of the *Pleiades*, that about ρ *Ophiuchi*, etc.—leads one to expect the continuous spectrum to match that of the Orion stars, in which case the dark lines would fail to show, for they would be covered over by the

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bright nebular lines of hydrogen and helium. While it is not possible to decide that the continuous spectrum is of the Orion type, it is nevertheless clear that it is not of the solar type, since none of the characteristic solar dark lines are present. In addition to the continuous spectrum and the better known bright lines of the nebula, many faint lines are present, some of which are doubtless new. These are perhaps for the most part fainter members of the known series; an example of such is furnished by the helium line between $H\beta$ and N_2.

Another long exposure spectrogram was made with the same instrument, with the slit placed E-W near the Trapezium. This presents a generally similar spectrum. The definition is especially good far into the violet and many fine emission lines show there, chiefly of the hydrogen series, several of them on the more refrangible side of λ 3727 in the ultra violet. On both these spectrograms the line λ 3727 is clearly resolved into its two known components. Fully forty bright lines are to be counted on this plate. It is of interest to note that N_1 and N_2 are much weaker relative to $H\beta$ on the east edge of the spectrum than on the west. The continuous spectrum is fainter on this plate, due mainly to a narrower slit than was used for the preceding plate, and like that plate this one shows no absorption lines. These plates show a disposition in the lines N_1 and N_2 to fade relative to hydrogen $H\beta$ toward the outer parts of the main nebula.

A spectrogram was also made of the nebular cloud about the bright star Bond 734 just north of the "fish-mouth," cataloged as N. G. C. 1982. The location of the slit was E-W over the brightest portion of the nebula. The plate of the spectrum of this nebula reveals a great difference in the relative intensity of the nebulium and hydrogen lines, implying a wide difference in the distribution of these two substances. There is also a great difference in the intensity of the line 3727 and the lines N_1 and N_2, suggesting that the so-called "nebulium" giving the latter lines is not responsible for the ultra-violet line. Thus we seem to have to do with "nebulium" I and "nebulium" II. The Trifid Nebula, for example, furnishes another example of this.

The helium line λ 4472 appears as a weak emission on the west edge of the nebula, and thus resembles "nebulium" I in distribution. The continuous spectrum varies in intensity over the nebula in a different way from that shown by the emissions, the

greatest variation being from the nebulium lines N_1 and N_2. It is strongest in the region of the bright star Bond 734, but there is no reason to think that direct light from the star has appreciably affected the plate, for the star was kept at a safe distance above the slit. It is a question whether the star by reflected light or otherwise is not responsible for the intensification of the continuous spectrum. Unfortunately the bright hydrogen lines of the nebula of course would cover the absorption lines of hydrogen that might belong to the continuous spectrum of the nebula. However, the helium bright lines of the nebula are faint enough to allow the helium dark lines partially to reveal themselves. This is best seen in λ 4388, less well in λ 4472, as the latter tho absorptive on the east edge of the nebula becomes a faint bright line toward the west edge, turning the balance from absorption to emission. Thus there is some evidence that the continuous spectrum of this nebula is that of a B type star.

A spectrogram of the more distant nebula N. G. C. 1977 in the region of C *Orionis* was secured. Slit was E-W. This nebula is rather faint and the slit was wide on that account. The emissions of this nebula are still less numerous and fainter than are those of the previous nebula (N. G. C. 1982). The spectrum is a continuous one crossed by only a few of the strongest of the bright hydrogen lines; no other of the nebular emission lines are recognizable on the plate. The absence of the bright lines N_1 and N_2 give the spectrum a strange appearance. There are present, however, helium absorption lines crossing the continuous spectrum. These are more clearly present than they were on the plate of the preceding nebula.

Still more distant from the Great Orion Nebula about θ *Orionis* is the nebula N. G. C. 2068, located in a region remarkably devoid of stars, north and a little east of ζ *Orionis*. The spectrum of this object has also been photographed. Here even the hydrogen emissions fail and the spectrum is continuous, crossed by hydrogen and helium absorption lines, the former series strong, the latter weak, as in advanced B type stars. There are two or three stars involved in this nebula, and the nature of the spectrum suggests the interpretation the writer placed upon other similar cases: that the nebula is apparently illuminated by reflected star light. This object is in a region of the sky strikingly deficient in stars, which is true of the other objects giving spectra of this type. This implies

that the light of the more distant stars is being absorbed by the nebula, which extends generally much beyond the evident limits of its luminous portion.

The spectra of these nebulae have been described in the order of their distances from the Great Nebula. The spectra, it has been seen, vary from the usual emission type of a gaseous nebula to the absorption type, with some sequence from one type to the other. If these nebulosities are to be regarded as parts of one great nebulous formation centering about the Trapezium, and it seems that they are really such, then the variation in the spectrum may be said to begin in the center with the usual emission type which loses strength (different substances differently) with distance outward and ends finally, in the most distant masses, with a continuous spectrum of the normal stellar absorption type.

Without doubt the spectrum of Pickering's encircling cloud would convey information of such value in nebular investigations as to be worth the effort to secure it even tho its faintness makes it an exceedingly difficult subject for the spectrograph.